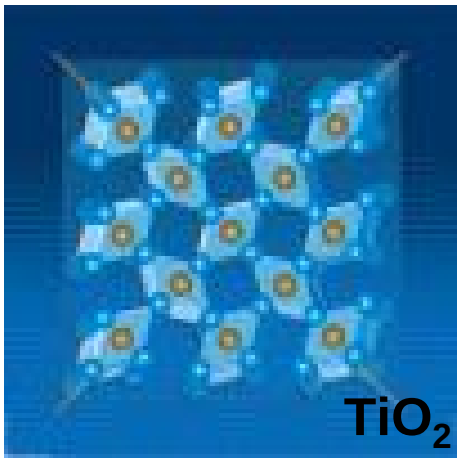
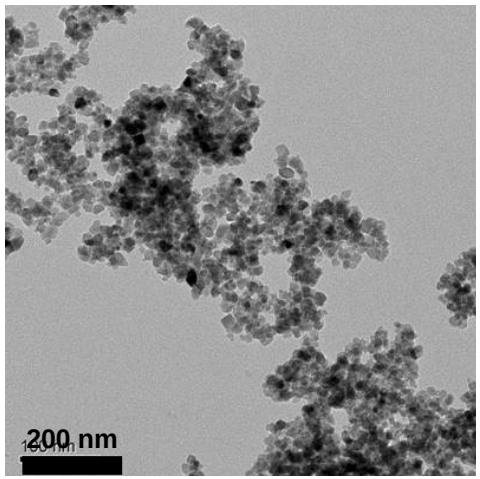
Candidate Nanomaterials

Prepared by V. Colvin

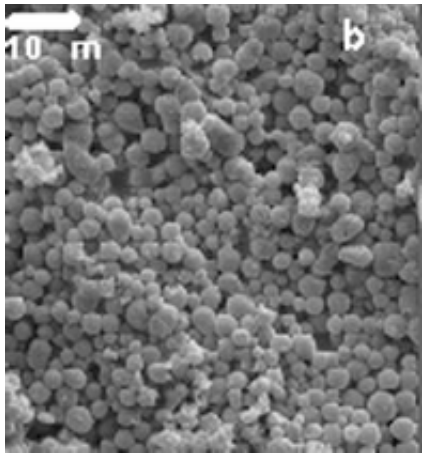
Nanocrystalline Titanium Dioxide (Titania)



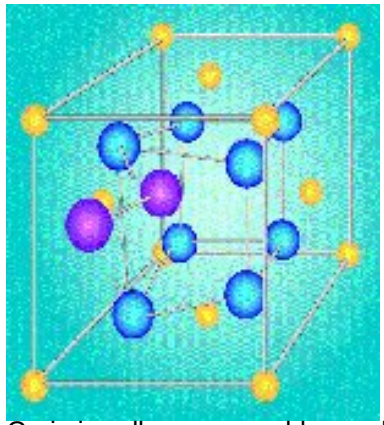


Molecular formula: TiO_2, can exist in brookite, anatase and rutile form
Commercial availability and uses: Many commercial sources of nano-titania; used in sunscreens and other cosmetics; future applications in solar cells and photocatalysis
Typical size and format: Commercial materials typically > 10 nm grain size and sold as dry powders; laboratory materials can be size controlled (d = 3 to 20 nm) and monodisperse
Surface coatings: Inorganic coatings available to minimize free radical production; rarely sold as a suspension; laboratory materials can be coated with polymers to impart solubility
General properties: Titania is a wide band gap semiconductor; materials are strong absorbers of UV-A light; with appropriate phase composition after uv excitation materials can generate •OH in water; low solubility material
EH&S Publications (ICON Database):118 (all oxides)

Nanocrystalline Ceria



From www.rsc.org



Ceria is yellow, oxygen blue and oxygen vacancies purple

Ceria powder - hygroscopic

Molecular formula: CeO_2 (common) or Ce_2O_3 (less common) often mixed or doped to increase its applications

Commercial availability and uses: Many commercial sources of nano-ceria; used as fuel cell electrolyte (when doped); an additive to diesel to increase efficiency (Envirox); abrasive in chemical mechanical polishing of IC circuits

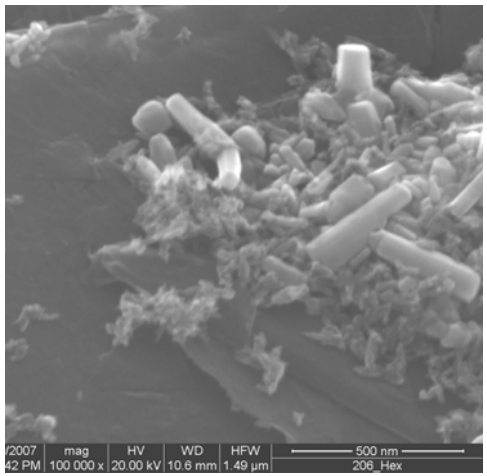
Typical size and format: Commercial materials typically > 10 nm grain size and sold as dry powders; laboratory materials can be size controlled (d = 3 to 20 nm) and monodisperse

Surface coatings: Rarely sold as a suspension; most interest in this material aimed as its use to develop fuel cell cathodes or as a dopant in gasoline

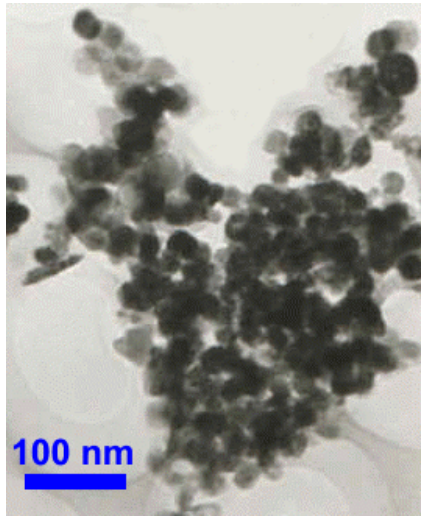
General properties: Refractory oxide – most of unique catalytic properties arise from presence of oxygen vacanices. Less photoactive than titania or zinc oxide. Bulk form used in catalytic converters

EH&S Publications (ICON Database):118 (all oxides)

Nanocrystalline Zinc Oxide



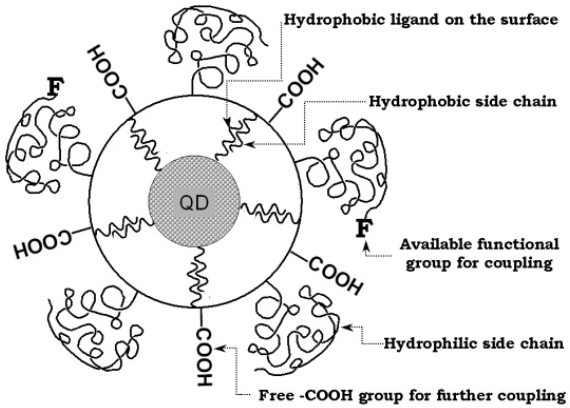
www.lbl.gov

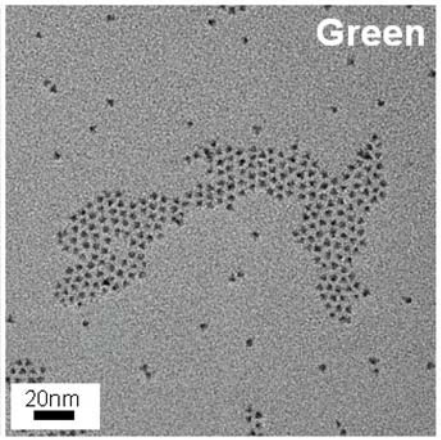


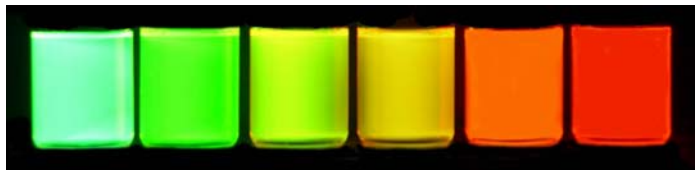
Nanoamor (inc)

Molecular formula: Zinc Oxide
Commercial availability and uses: It is used in sunscreens; also much interest in its wire form for sensing applications (mainly academic)
Typical size and format: Commercial materials typically > 10 nm grain size and sold as dry powders; laboratory materials can be size controlled (d = 3 to 20 nm) and monodisperse
Surface coatings: Laboratory materials can be coated with polymers to impart solubility
General properties: Zinc oxide is a wide band gap semiconductor; materials are strong absorbers of UV-A light; it is soluble in acids or alkalis
EH&S Publications (ICON Database):118 (all oxides)

Quantum Dots (primarily II-VI)

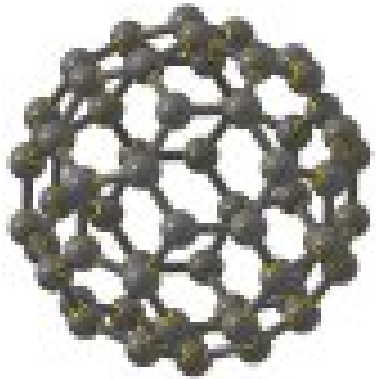


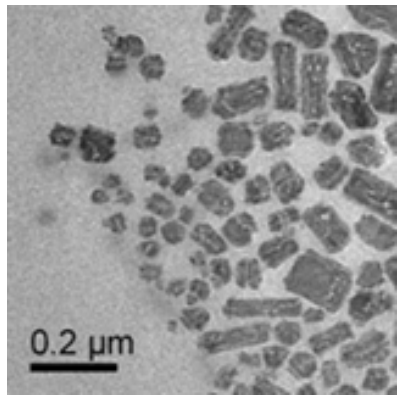




Molecular formula: CdSe – for example; term includes CdX (X=S,Se,Te); PbX (X=S,Se,Te); ZnX (X=S,Se,Te) – often core-shell with interior material surrounded by higher bgap
Commercial availability and uses: Commercial suppliers include Invitrogen who sells for biomedical imaging both research and in-vivo; Endarken sells for solar cell and LED applications (nascent)
Typical size and format: Commercial materials are monodisperse with core dimensions 2 to 8 nm; overall hydrodynamic size can be up to 50 nm
Surface coatings: Polymeric coatings are standard on quantum dots; controlled water solubility is a goal and for electro-optical use polymer coatings facilitate charge separation
General properties: Quantum dots are nanoscale forms of direct gap semiconductors; their strong absorption and emission can be tuned throughout uv/vis/NIR
Web of Science Hits (Nano* + Cd/Zn/Pb/S/Se/Te):
EH&S Publications (ICON Database): 26 (all semiconductors)

C_{60} or C-sixty





Aggregated c-sixty

Molecular formula: C-sixty is a well recognized molecule; it can become aggregated at sparing concentrations in water

Commercial availability and uses: MER corporation and Frontier Carbon are two well known producers of high purity C-sixty; applications include both anti-oxidants in face creams as well as additives in fuel cells.

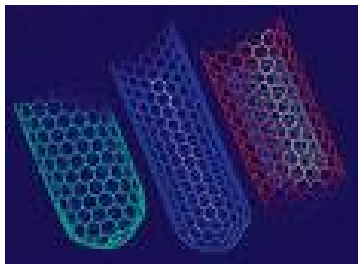
Typical size and format: Sublimation techniques are used to make the material pure; sold as black powder; some covalent derivatives are available as well

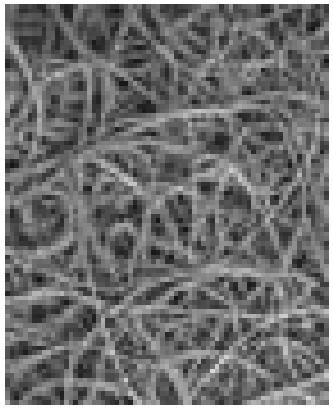
Surface coatings: PVP polymers can be used to stabilize in water; surfactants may also facilitate the water solubilization of this material

General properties: C-sixty is considered an inorganic material, closely related to graphite. It has many unique chemical, optical and electronic properties.

EH&S Publications (ICON Database): 195 (all carbon)

Single-walled Carbon Nanotubes



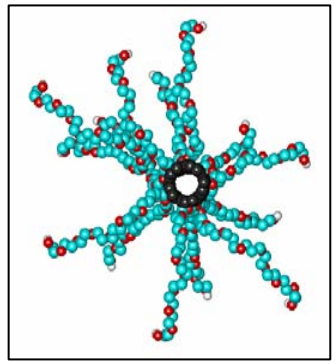


"Mat" of SWNT
Helix materials

Dispersed with Surfactant

No treatment

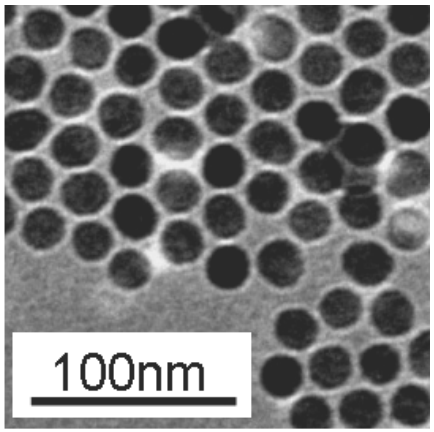
www.nanomaterialstore.com

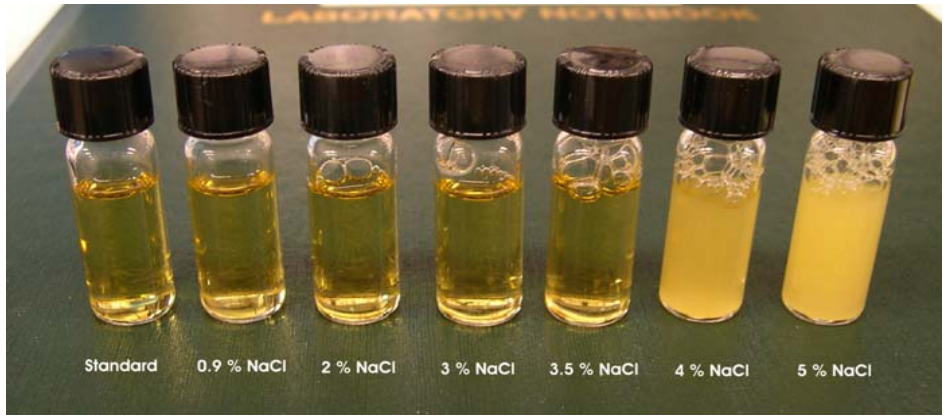


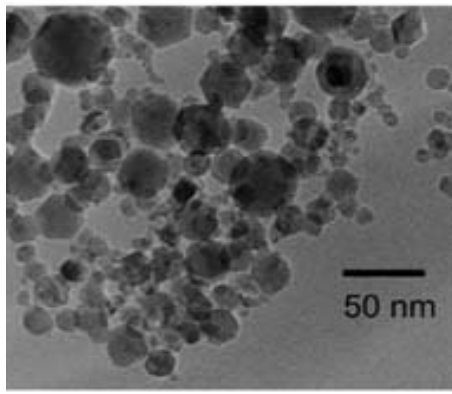
SWNT with surfactant
(Ma, Rice U)

Molecular formula: Carbon nanotubes are generally pure carbon; depending on the twist of the tube they can be metallic or semiconducting, and also can have variable length
Commercial availability and uses: Commercial suppliers abound (greater than 5)
Typical size and format: Commercial materials are black powders sold with varying levels of impurities (mainly remnants of metals catalysts); rather extreme purification techniques must be used to generate pure materials
Surface coatings: Polymeric coatings are becoming standard; can also use direct covalent functionalization as well as surfactants. The black powders as-is are not very water soluble
General properties: Like c-sixty SWNT have unique electrical and optical (near-IR emission) properties. Their chemical properties are less pronounced than spherical carbon nanostructures.
EH&S Publications (ICON Database): 195 (all carbon)

Iron Oxide Nanocrystals



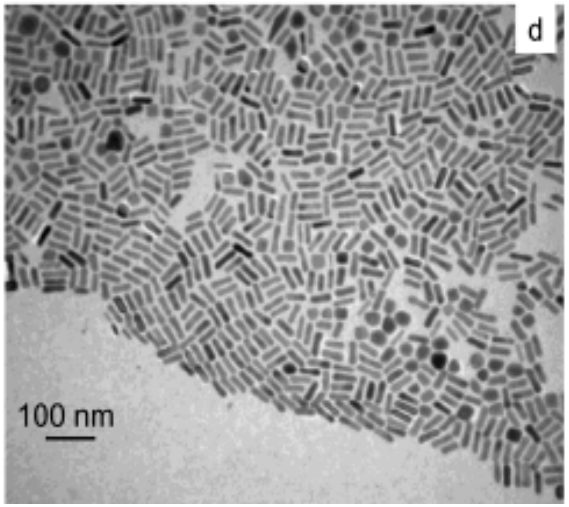


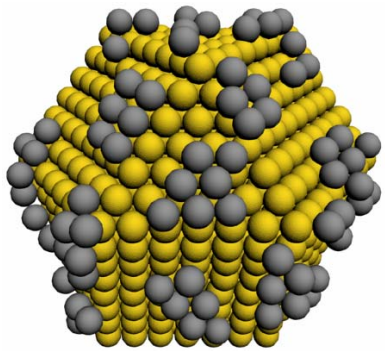


Iron oxide nanocrystals, in water, variable NaCl

Molecular formula: Iron oxide can exist in a multitude of crystal phases and iron oxidation states. The most common is Fe_3O_4 – magnetite.
Commercial availability and uses: There are many suppliers for iron oxide powders (see upper right image); water soluble iron oxide is used as MRI contrast agents.
Typical size and format: Powders are generally agglomerated and polydisperse; for biomedical applications coatings are included to create isolated and water stable systems
Surface coatings: Both polymers and surfactants are used to impart water solubility
General properties: The magnetic properties of nanoscale iron oxides are distinctive; they can be used for MRI imaging to enhance contrast; as dopants to permit rf-inductive heating of tissue; in memory storage applications
Web of Science Hits (Nano* + iron*):
EH&S Publications (ICON Database): 118 (all oxides)

Gold Nanoparticles





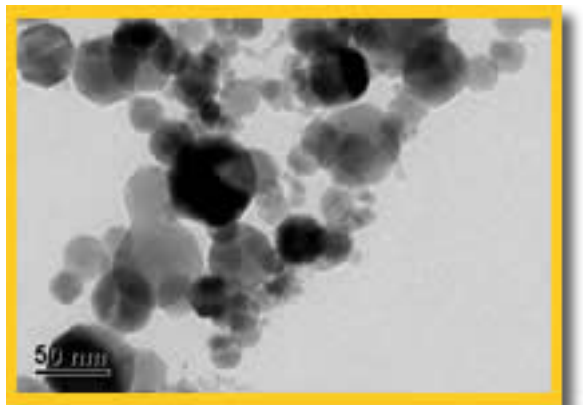
Au/Pd Catalyst
From M. Wong

www.mesogold.com

Molecular formula: Gold. Some smaller gold nanoparticles are called by the number of atoms (e.g. Gold-55)
Commercial availability and uses: Commercial suppliers are limited mainly to the biomedical markers arena
Typical size and format: Most materials are sold as suspensions. The development of shape controlled materials is of great academic interest (upper left)
Surface coatings: Polymeric coatings are standard; controlled water solubility is a goal for near-infrared imaging
General properties: Gold nanocrystals have strong visible emission; when made as arod their plasmon resonance shifts to the near-IR; also used in electron microscoy labeling.
EH&S Publications (ICON Database): 102 (all metals)

Silver Nanoparticles

Nanotechnologies, Inc.



25 nm Ag Nanocrystals

Molecular formula: Silver.
Commercial availability and uses: Silver nanoparticles have recently received much interest for their anti-bacterial applications
Typical size and format: Most materials are sold as powders.
Surface coatings: Surface coatings are less available in the commercial arena where surface access is thought to be important for applications
General properties: Silver nanoparticles have strong visible absorption and also notable anti-microbial qualities
EH&S Publications (ICON Database): 102 (all metals)